

Cadmium

USGS Report:

“Cadmium risks to freshwater life, derivation and validation of low-effect criteria values using laboratory and field studies” (2006)

Virginia DEQ Staff Presentation

Four Different Assessments Available for Cadmium

| Criteria: | Acute (ug/L) @ hardness 100 | Chronic (ug/L) @ hardness 100 |
|----------------------------------|----------------------------------------|------------------------------------------|
| Current VA (EPA 1984) | 3.9 | 1.1 |
| EPA 2001 | 2.0 | 0.25 |
| Chadwick (2004) | 1.8 ? | 0.47 ? |
| USGS (2006) | 1.3 | 0.57 |

Quick Review of How Water Quality Criteria for the Protection of Aquatic Life are Calculated

Summary of Methodology Used to Calculate Water Quality Criteria

1. Identify all acceptable toxicity tests and quality of information available.
2. Ensure needed variety of species in the data set to ensure wide range of species covered.
3. Develop data set of all acute toxicity data ranked by genus and species.

Criteria Methodology (continued)

4. Calculate the means of LC_{50} values for each species,
5. If hardness affects toxicity, normalize all LC_{50} values to a standard hardness level.
6. Calculate the mean of all normalized LC_{50} values for the same species to get a species mean acute value (SMAV).
7. Calculate the genus mean acute value (GMAV) for all species in the same genus.

Criteria Methodology (continued)

8. Rank all GMAVs in order of sensitivity, e.g. most sensitive = rank # 1
9. The total number of genera in the dataset and the actual GMAV concentrations for the four most sensitive genera are used to calculate the 5th percentile of the distribution, which = the final acute value (FAV).
10. This FAV is the basis for the acute criterion and usually the chronic criterion also.

The Final Acute Value is the Basis for the Acute and Chronic Criteria

The acute criterion = FAV/2

The chronic criterion = FAV / FACR

ACR = Acute to Chronic Ratio:

$\frac{\text{Acute value (LC}_{50})}{\text{Chronic value}}$ (from same toxicity test)

FACR = mean of several ACRs determined to be appropriate, based on the pollutant's dataset

USGS report on reassessment of the cadmium criteria (freshwater)

- Complete reassessment.
- New toxicity data (acute and chronic)
- Reassessment of the hardness-toxicity relationship
- New acute and chronic criteria recommended
- Assessment of potential risk to endangered species
- Assessment of potential for field effects

USGS; a few deviations from guidelines

1. Guidelines gives priority to flow-through data; USGS used flow-through, renewal and static test results equally if otherwise acceptable.
2. Guidelines would allow unmeasured test results; USGS used only measured test results
3. Guidelines gives preference to life-time chronic tests over shorter term tests. USGS also used shorter term tests if the results were more sensitive or similar in sensitivity to life time tests.

Technical rational was provided for these derivations. Three of four peer reviewers concurred with deviations.

Differences In USGS Report

- USGS included chronic data from studies with shorter durations than specified in EPA's Criteria Guidelines.
- USGS presents information that recent studies indicate that some shorter duration chronic studies provide useful data comparable to long-term tests and should not be ignored.
- These shorter-term tests typically do not provide data on growth however.

Chronic Data; some different values used by USGS and Chadwick

- USGS used “chronic” values as MATCs (geo-mean of NOAEC & LOAEC) or regression analysis of a low percentage effect concentration. Generally follows EPA Guidelines or precedents.
- Chadwick sometimes used LC_{50} values from some chronic tests as a chronic value (concern; LC_{50} is not a minor effect)

Hardness-toxicity relationship reassessed and revised adjustment calculated

| Criteria Source | Acute pooled slope | Chronic pooled slope |
|-----------------|-----------------------|-------------------------|
| EPA (2001) | 1.0166 | 0.7409 |
| Chadwick | 0.9151 | 0.7998 |
| USGS | 0.8368 | 0.6247 |

Comparison of Acute Data

(all FAV & criterion values are ug/L @ hardness 50)

| Criteria Source | # test values | # of Genera | FAV calculated | Final Criterion Value |
|------------------------|----------------------|--------------------|-----------------------|------------------------------|
| EPA 1984 | 133 | 44 | 4.4 | 1.8 |
| EPA 2001 | 226 | 55 | 1.4 | 1.0 |
| Chadwick 2004 | 226+17 = 243 | 56 | 1.9102? | ?FAV/FACR 2.7362) |
| USGS 2006 | 279 | 57 | 1.2 | 0.75 |

USGS Cd; Acute Data and FAV

(at hardness = 50)

| rank | GMAV | <i>Genus</i> |
|----------------|-------------|---------------------|
| 4 | 2.610 | <i>Cottus</i> |
| 3 | 2.610 | <i>Salmo</i> |
| 2 | 2.126 | <i>Salvelinus</i> |
| 1 | 2.019 | <i>Oncorhynchus</i> |
| Total # genera | 57 | |
| FAV | 2.451 | |

USGS Developed Enough Chronic Values to Allow for Direct Calculation of Chronic Criterion Without Using a FACR

Calculated final Chronic Value the same
way as a FAV

Comparison of Chronic Data

(all FCV & criterion values are ug/L @ hardness 50)

| Criteria Source | # test values | # of Genera | Chronic Value (Calculated) | Final Criterion Value |
|------------------------|----------------------|--------------------|---------------------------------------|----------------------------------------------------|
| EPA 1984 | 25 | 13(44) | 0.66 | 0.66 |
| EPA 2001 | 34 | 16 | 0.17 | 0.17 |
| Chadwick 2004 | 34+12 = 46 | 16 | ?0.295 | 0.268 _(cv) to 1.125 _(ACR) |
| USGS 2006 | 93 | 21 | 0.39 | 0.39 |

USGS Cd: Chronic Data and FCV

(at hardness = 50)

| rank | GMCV | <i>Genus</i> |
|----------------|-------|-------------------|
| 4 | 1.281 | <i>Salvelinus</i> |
| 3 | 1.004 | <i>Gammarus</i> |
| 2 | 0.838 | <i>Cottus</i> |
| 1 | 0.326 | <i>Hyaella</i> |
| Total # genera | 21 | |
| FCV | 0.39 | |

USGS Recommended Cadmium Criteria

Acute:

$$e^{(0.83675 \times \ln(\text{hardness}) - 3.5602)}$$

Chronic:

$$e^{(0.6247 \times \ln(\text{hardness}) - 3.384)} \times (\text{conversion factor})$$

(No conversion factor needed for acute criterion because the FAV was based on dissolved values)

Comparison of Criteria

| Criteria: | Acute (ug/L) @ hardness 100 | Chronic (ug/L) @ hardness 100 |
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USGS calculated a Final Acute Value that was under-protective of important species

Total # of genera = 57

Calculated FAV (@ hardness of 50) = 2.451 ug/L

Following EPA Guidelines, this FAV was lowered to the species acute value of 1.50 ug/L for cutthroat trout to protect the important species of trout with acute sensitivity < the calculated FAV;

cutthroat trout SMAV 1.50

rainbow trout SMAV 2.07

bull trout SMAV 2.13

Most sensitive USGS acute data

| GMAV rank | GMAV | SMAV | Genus | Common name |
|-----------|------|------|---------------------|-----------------|
| 1 | 2.02 | 1.50 | <i>Oncorhynchus</i> | Cutthroat trout |
| 1 | 2.02 | 2.07 | <i>Oncorhynchus</i> | Rainbow trout |
| 1 | 2.02 | 2.67 | <i>Oncorhynchus</i> | Chinook |
| 2 | 2.13 | 2.13 | <i>Salvelinus</i> | Bull trout |
| 3 | 2.61 | 2.61 | <i>Salmo</i> | Brown trout |
| 4 | 2.61 | 2.61 | <i>Cottus</i> | sculpin |
| 5 | 3.32 | 3.32 | <i>Etheostoma</i> | darter |